Annual Project Summary

Characterization of Subsurface Sediments for Liquefaction Hazard Assessment, Southern San Francisco Bay Area

Program Element: I and II
Key words: Regional Seismic Hazards, liquefaction, amplification, geologic mapping

U.S. Geological Survey
National Hazard Reduction Program

Award Number 99-HQ-GR-0097

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NON-TECHNICAL SUMMARY

Communities bordering the San Francisco Bay are underlain by young sediments. In addition, development has encroached onto the Bay margins on artificially placed fill. These young, loose sediments and artificial fills experienced significant occurrences of liquefaction with associated damage to overlying buildings and other structures during the 1906 San Francisco and 1989 Loma Prieta earthquakes. The objective of our study is characterize the distribution, thickness, and properties of the young sediments and overlying artificial fill within the southern Bay area. This information is ultimately required to produce maps showing areas underlain by sediments that may liquefy during an earthquake. These maps can then be used for emergency response, planning, engineering, and risk mitigation. Toward this ultimate objective, we currently are compiling and interpreting subsurface data, to produce a series of 1:24,000-scale interpretive, digital maps for the southern San Francisco Bay, including the densely populated Santa Clara Valley.

INVESTIGATIONS UNDERTAKEN

Historically, localized liquefaction-induced ground failure and site amplification have been a major cause of damage to property and lifeline facilities during large-magnitude earthquakes in the San Francisco Bay area. Liquefaction produced by the October 17, 1989 Loma Prieta earthquake resulted in significant damage to bayshore areas on the borders of the bay. Local site effects exerted a strong influence on both the occurrence of liquefaction and the severity of ground shaking throughout the affected region (EERC, 1990). As a result, major structural damage and corresponding loss of life was concentrated at a few sites underlain by young sediments and artificial fill which failed during liquefaction and/or amplification of strong ground motions produced at the ground surface.

A significant need exists therefore for detailed, quantitatively-derived liquefaction hazard maps that would illustrate the likely distribution and magnitude of these effects during future large earthquakes in the San Francisco Bay Area. Production of maps at a scale of 1:24,000 are required for urban planning. Because the lithologic and engineering properties of sediments along the Bay margins typically vary both laterally and with depth, it is necessary to interpret surface and subsurface data within a geologic context that accounts for the depositional environment of sediments. Additionally, artificial fill along the Bay margins in most instances has been placed directly on top of Holocene sediments that were uncharacterized at the time of fill placement, and currently covered. The interpretation and extrapolation of compiled borehole data therefore requires a firm understanding of the complex depositional history of the San Francisco Bay.

Our ongoing research is designed to provide the three-dimensional geologic framework required for quantitative assessment of liquefaction hazard. Our methodology emphasizes delineation of the thickness and lateral continuity of liquefiable sediments. During our first year of research, we have compiled subsurface boring logs representative of surface and subsurface deposits within the southern San Francisco Bay Area. We have begun interpreting these subsurface data to produce a series of 1:24,000-scale interpretive maps for the central and southern San Francisco Bay that delineate the elevation of the top of Pleistocene deposits. These maps will be completed by February, 2000, and, with the completed database, form the basis for the production of interpretive maps in our proposed second phase of research.

INITIAL RESULTS

Our phased project plan builds on the approach employed by Helley (1990) to delineate the top of Pleistocene deposits in the Santa Clara Valley, within the southern part of our proposed San Francisco Bay study area (Figure 1). Helley (1990) contoured the top of Pleistocene deposits within Santa Clara Valley using CALTRANS geotechnical borings. Helley's map has contributed to the understanding of the subsurface structure of the Santa Clara Valley and has since been used to estimate the thickness of liquefiable sediments for a local liquefaction hazard evaluation (e.g. Powers et al., 1992). The top of Pleistocene deposits typically is accompanied by a notable increase in penetrometer resistance that coincides with a marked reduction in liquefaction susceptibility with depth. Therefore the top of Pleistocene deposits represents the probable base of

potentially liquefiable deposits within the Bay area. We have begun to refine Helley's existing map (Helley, 1990), by incorporating recent CALTRANS geotechnical data and data collected for construction (e.g. airport expansion, earthquake retrofits, new construction) and remediation sites (e.g. EPA Superfund sites, with assistance from the Santa Clara Water District). We currently are compiling borehole data, over 1200 subsurface boring logs to date, and performing similar mapping of the top of Pleistocene deposits beneath Holocene flatlands to extend this mapping to the rest of the southern San Francisco Bay study area.

TECHNICAL AND NON-TECHNICAL REPORTING

The target audiences for data derived from this study are the planning and government agencies responsible for earthquake hazards reduction and risk mitigation in the San Francisco Bay Area. In addition to generating technical and non-technical reports required by the award contract, we anticipate producing a digital database of archival information and a series of digital maps. To ensure that the scientific community will have the opportunity to provide input into our research efforts, we will share our data directly with the U.S. Geological Survey, the California Division of Mines and Geology, and interested university researchers and private consultants.

The final maps produced by this study will be supplemented by technical and non-technical reports that provide documentation of the sources of information, methods of data collection and analysis, and recommendations for use and application of the maps. We anticipate conducting formal and/or informal presentations with local municipalities (e.g., Santa Clara County, City of San Jose, etc.) and at USGS-sponsored or other workshops relevant to earthquake hazards. Lastly, we anticipate producing a refereed journal article and presenting the results at a major professional society meeting.

Preliminary results of this study, including raw data and draft maps, are in ESRI Arcview 3.1 format. Compiled subsurface data is being compiled in Microsoft Excel 4.0 format.

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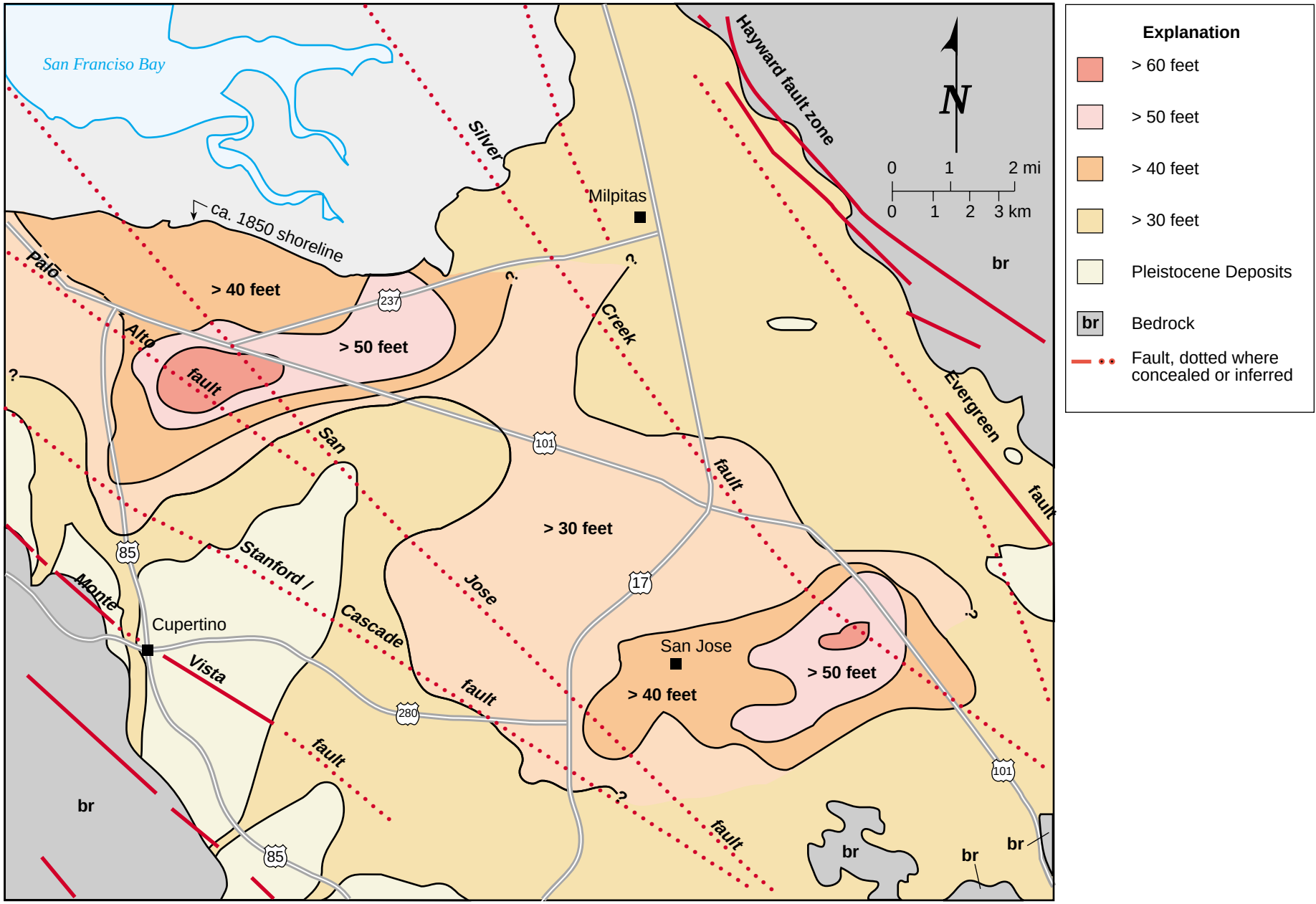

Figure 1. Generalized map of the Santa Clara Valley showing thickness of Holocene deposits derived from Helley (1990); major faults (after Bortugno et al, 1991); and surficial deposits (Helley, 1990).